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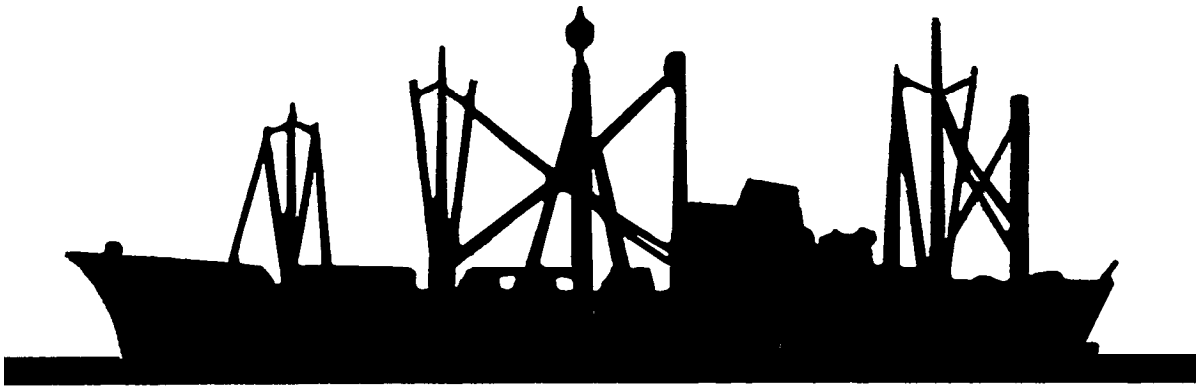

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

IREAPS

HUMAN PERFORMANCE ENGINEERING: ON REVERSING THE PRODUCTIVITY SLOWDOWN

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ABSTRACT

In this paper a human performance engineering approach to increased work productivity is outlined. Three applications are summarized by way of illustrating its major advantages and features, one in manufacturing, one in a service, and one in a sales setting. The ingredients of this approach start with a precise statement of desired company objectives in terms of behavior changes that may be required of individual workers. An accurate and reliable behavior counting system is needed next to learn exactly what workers are doing so that graduated steps toward the final behavioral adjustment can be planned. A feedback system in the form of individual, public charting is then to be introduced. Following a suitable period, a potent and relevant positive consequence consistently should be given for behavior increases or for maintenance of an acceptable performance. Various safeguards, tests for effectiveness, and implications are discussed.

There seems little need to document either the fact or the consequences of the post-1967 productivity slowdown in the U.S. to a group that explicitly is dedicated to productivity increase. I assume that each of you know of the catastrophic consequences of this slowdown (coupled with occasional periods of actual decline) for a nation that is founded upon the principles of competition and free enterprise as well as for each and every individual that comprises the population of that nation. Accordingly, I also assume that this audience is chronically vigilant in their search for factors that may address this slowdown. Finally, it is presumed that each of you courageously would experiment with any means that showed promise to "undo" our current attenuated Productivity level. I am here to present to you one such possible "means."

However, a disclaimer may be needed before proceding further. you should note that I have not been invited to tour, explore, or discuss with anyone the explicit productivity problems that are endogenous to shipbuilding. This means that I have no data from productivity experiments/projects such as we have been gathering elsewhere that directly bears on this important area of manufacturing. Fortunately, I often have presented to groups for which I have not had specific examples and the results have been encouraging. These groups include civil engineers, army civilian administrative personnel, productivity directors in the aerospace, food processing, and petroleum industries, steel founders, and many, many others. These groups have found that our data and principles readily can be applied to their respective settings and accordingly have sometimes been able to set prototype programs in place! Noteworthy in this connection is the invariant comment from these groups that (1) because of the putatively radical departure in our perspective about human activity from much of what they previously had been exposed to and (2) because

of the seeming pronounced effects that we report, a well-delineated context is needed in order to evaluate and perhaps appreciate the forthcoming information.

In response to this request for a contextual frame, it has been our finding that marked productivity gains often can be achieved through the proper application of a people-change technology. Changes in how people relate to tasks, to their managers, and to their own history qualify here. This paper accordingly is concerned with changes in what, where, when, and with whom people work and how these changes can result in important productivity gains. Opinion surveys from the past 15 years tell us that changing persons may be more difficult now than in past decades, however. Opinion trends within the U.S. work force show that work attitudes likely have undergone precipitous change from those following World-War II and through the late 1960s.

Whereas the majority of the work force purportedly "respected" their managers, "trusted" their companies, and believed that hard work "paid off" during the early post-war period, the majority now appear quite different in these regards. Over 70% of those surveyed feel that they currently can disagree with their supervisors, that businesses in general are untrustworthy and deceptive, and that their labors often go unnoticed and unappreciated. Moreover, the current work force, now more top heavy than ever before with inexperienced youth and females, appears much more likely than in post-war times to voice their opinions, to insist upon input regarding both their own work assignments and company operations, to request participation in decision making, and so on. And, if these requests are not met, evidence is mounting that a majority of workers have learned to subtly withdraw, hold back, and attenuate involvement rather than quit their jobs. All of these apparent differences in the character of our current work force likely reflect the byproduct of the greater

sophistication, worldly perspective, and social awareness that accompanies a higher overall educational level and increased exposure to the multi-modal communications "advances" of the past two decades.

According to the pollsters, one consequence of' these seeming attitudinal alterations in the contemporary work force is that old management "styles'! and traditions simply will not suffice. These opinion analysts accordingly predict little success for those tradition-bound managers that believe it their job "to give rather than to receive heart attacks," or that they are "the thinkers" and their supervisees are "the workers." This latter "bring-body-leave-brains-at-home" philosophy will not suffice as a means of reconciling today's work force with increased work, company involvement, and with the spirit of challenge that may be needed to reverse the current, disastrous slowdown.

The people-change approach to increased productivity is confronted with yet another problem besides that of a putatively more demanding (petulant?), sophisticated, and jaundiced work force. There are almost as many so-called work-improvement programs as there are organizations that employ them. Moreover, those that champion these programs often have been unusually noncritical in their claims of benefits and values (cf., Cummings & Molloy, 1977), remiss in poviding sufficient detail, are short on rationales for the procedures that were used, and often indifferent in the use of rigorous procedural safeguards typically believed necessary for drawing firm conclusions (cf., Campbell & Dunnette, 1968; Goldstein, 1980). Representative of these work-improvement programs include autonomous work groups, organizational restructuring, flexitime, participative decision making, job restructuring, management-by-objectives and goal-setting, task- or interpersonal-oriented.team/group approaches, transactional analysis and, perhaps, quality circles.

Although each of these work-improvement programs presume somewhat different "manipulations" or so-called "action levers" (Cummings & Molloy, 1977) for their effectiveness, it nonetheless is possible to discern at least two features that are common to all. First, with the possible exception of the (unmentioned) Scanlon Plan, the aforelisted programs rest heavily upon "antecedant" means to change work performances. By antecedant is meant that various putative non-performance features of the person---such as an internal state, condition, or mental process--.-must be altered as a prerequisite to work changes. As examples, certain of these work-improvement programs variously are dedicated to increasing "committment" (the antecedent state) to specified goals, "intentions/convictions" to work harder/longer, positive "feelings" about job and/or company, and so forth. These alleged antecedant-state changes are seen as propadeutic to improved work. They are antecedant in the sense of being precursors to the desired performance.

The second common ingredient of the above-listed programs is that most do not rest upon firm empirical evidence. Actually, evidence of two sorts is needed for the validation of these antecedant-oriented approaches. The first pertains to documentation regarding the alleged change that occurs in the antecedant condition per se. The question of importance is whether such alleged entities as commitment, espirit de corps, job satisfaction, and so forth actually undergo alteration as a result of exposure to the program under consideration. Evidence for this kind of change refers to the internal validity (Campbell & Stanley, 1966) of a program. Unfortunately, there is a paucity of evidence of this sort for any of the above-listed work programs (cf., Cummings, Molloy, & Glen, 1978). Clearly, without firm information of this kind, there would be little value in assessing whether the program under question influences external measures of importance to the organization per se, If internal changes

either do not occur or are not well understood, there is little utility in looking for the *influence* of such changes upon company operations! Yet, the latter is the "proof of the pudding," so to speak. The second question to be answered thus is whether the program actually improves some aspect of human .

Again, while there have been many claims that each does, i.e., decreases costs, or waste, or withdrawal, increases productivity, or quality, rigorous evidence is even more sparce in these regards than for internal changes! This latter kind of evidence is tantamount to concerns regarding external validity, and constitutes the sine qua non or foundation that any work-improvement program must have if it is to be a viable option in addressing the present productivity slowdown. Perhaps the most recent testimony as regards these hiatuses in evidence for current antecedant approaches is that summarized by Woodman and Sherwood (1980) regarding the "team" or "groups" approach to work improvement. Their conclusions *regarding* both internal and external validity for the latter are fully consistent with those of the present article regarding most extant work-improvement programs. A final comment here is that even were the evidence both greater and of better quality regarding both the internal and external validity of these approaches, each poses the further untested concern of general applicability. Clearly, any program of work improvement will be of interest to productivity experts the degree to which it readily can be adapted to the manifold work settings that prevail in our complex culture. Unfortunately, many of the above-listed strategies, even if ultimately proven externally valid, seem quite limited in this connection. For example, autonomous work groups and job redesign likely have quite restricted application because of the larger problems they pose for organization restructuring and overhaul, materials handling, and so forth.

Human Performance Engineering: A Possible Solution?

The people-change approach to work improvement espoused in this report rests upon an entirely different information base than the above-listed strategies. In order to appreciate the potential value of this programmatic approach, three projects are summarized in varying detail below. These were selected because (1) each represents an application to one of the three major divisions of human work (sales, service, and production), (2) each repetitiously illustrates the basic ingredients of this approach, and thereby, the broad applicability it may have for bringing about work changes regardless of setting, work population, or business endeavor, and (3) they provide a solid basis for the conclusion that its major ingredients can be guaranteed to work when properly implemented. Thus, following an exposition of these three projects, the step-by-step ingredients that should be followed in any performance-engineering project "package" will be outlined as a technology, the underlying theoretical basis for each will be revealed, and why these ingredients always work will be discussed.

Project one: Human performance engineering in a manufacturing setting. This project was undertaken because one of two major plants of a medium-sized, midwest, furniture manufacturing company consistently reported an earned ratio that was considerably less than the plant located in the deep south. The earned ratio (expressed in terms of standard hours required to turn out the finished product/actual hours expended) was a mediocre .54 for the target plant and a laudatory .67 for the southern setting. Individual worker efficiency was targeted for modification as a remedy for this deficiency in productivity. An appropriate individual, daily measurement system already was in place in that each worker filled out a card designating exactly what they had done and the time frame involved. These scores were collected by

respective supervisors and submitted to the computer for conversion into average daily efficiency indices. Most workers thus understood the meaning of their efficiency measure, and that it reflected actions that directly were under their control. The overall project design involved preplanned department by department introductions of the ingredients of the performance-engineering program. These ingredients included systematic involvement of each level of plant management, including the plant superintendant. Program features within any given department included (1) collection of individual average efficiency indices, their register on 8-1/2 in x ll in specially-designed charts, and their study without worker or supervisor awareness for a minimum of eight weeks. Next (2), each individual chart was publicly posted in a conspicuous place and kept updated (by the department supervisor) by a.m. posting of the previous day's efficiency index. This procedure was followed for a minimum of eight weeks, and sometimes quite longer.

In the meantime, (3) supervisors received extensive training on the charting procedure, on learning emotional neutrality during the initial display period (baseline), and on how to praise and provide positive social supportiveness when efficiency either increased or was maintained at near l00%-of-standard level. This procedure of (1) covert charting, (2) neutral public display, and (3) efficiency-contingent supervisor supportiveness was augmented by (4) bringing on the second-level supervisor. (S)he in turn participated in a charting endeavor to publicly and daily display the percent of completed charts by respective supervisors. In addition, second-level supervisors aperiodically administered a behavior-rating scale to workers to obtain a "positivity" score for individual supervisors. These scores also were publicly posted. Both the second-level supervisor and plant superintendant were trained to dispense social support to those first-level supervisors that kept their supervisee charts up to date and who achieved "high" positivity ratings.

These program ingredients initially were introduced into the Fiberglas department wherein various of the program ingredients were perfected. During this period, overall department efficiency markedly increased, and subsequently has been maintained (three years to date) as shown in Figure 1. Then, on a temporally-staggared basis, these ingredients respectively were introduced into the upholstery, punchpress, welding, plating, polishing and buffing, packing, and mainline departments with successes ranging from modest but statistically reliable increases (upholstery department) to increases that were so marked as to not require statistical analyses for verification (all other departments). Some of these data are displayed in Figures 2-4. The efficiencies of the three lowest and three highest performers were averaged over departments and compared with the intermediate performers at each program point; namely, baseline, feedback, feedback plus praise and followup. These data, shown in Figure 5, clearly reveal uniform program influence across all individuals within and across departments.

The design of this project was multiple-baseline in nature and thus permitted conclusive revelation of the effectiveness of each program ingredient. In effect, each department was a separate replication that showed that only when charting (feedback) and/or charting plus praise was introduced, efficiency increased. This is clear evidence of internal validity for this work-improvement approach. External validity is shown in Figures 6 and 7that respectively reveal overall plant efficiency and earned-ratio increases over the tenure of the program as thus far undertaken. Overall, efficiency has risen from 84% to 96+% and the earned ratio from .54 to .665. Moreover, these gains nicely correlate with efficiency changes in individual departments.

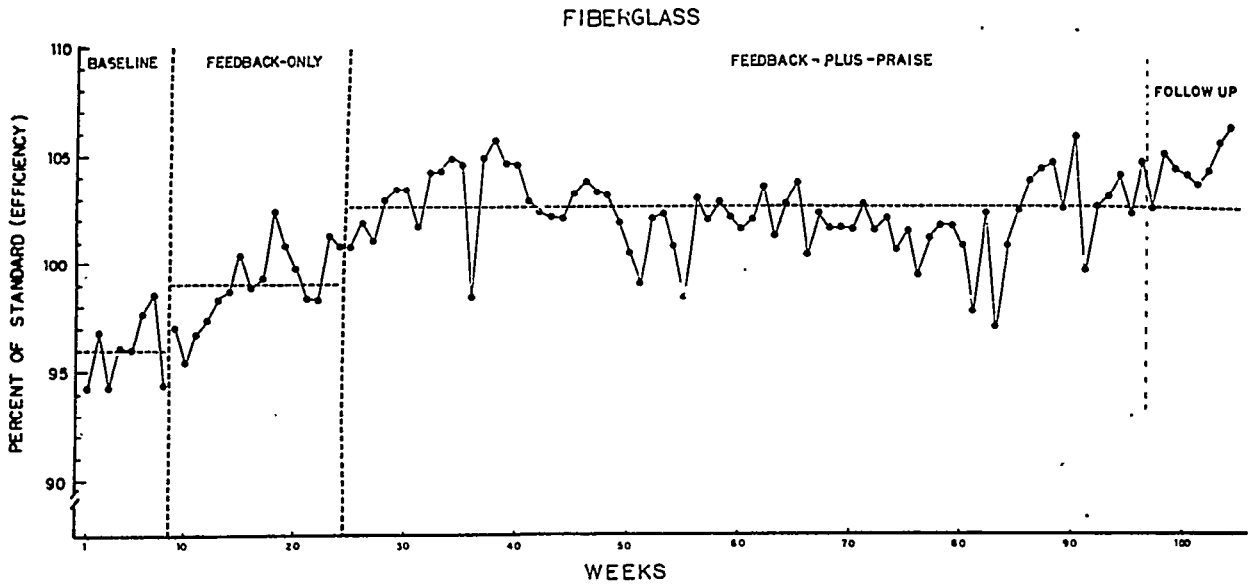

Figure 1. Average weekly efficiency of the Fiberglass Department. The initial. 8 weeks (baseline) depict department efficiency prior to introduction of individual charts (collected during the latter months of 1977). The next portion of the graph shows the mean efficiencies for the first and last 8 weeks for public charting per se (feedback-only); the next section depicts mean efficiencies for the next 72 weeks during which performance-contingent supervisor praise was added to the feedback procedure; and, the last portion represents an 8-week block sampled in the Spring of 1981 in order to show perseverative program effects. This portion simply reflects the effects of continued feedback and praise.

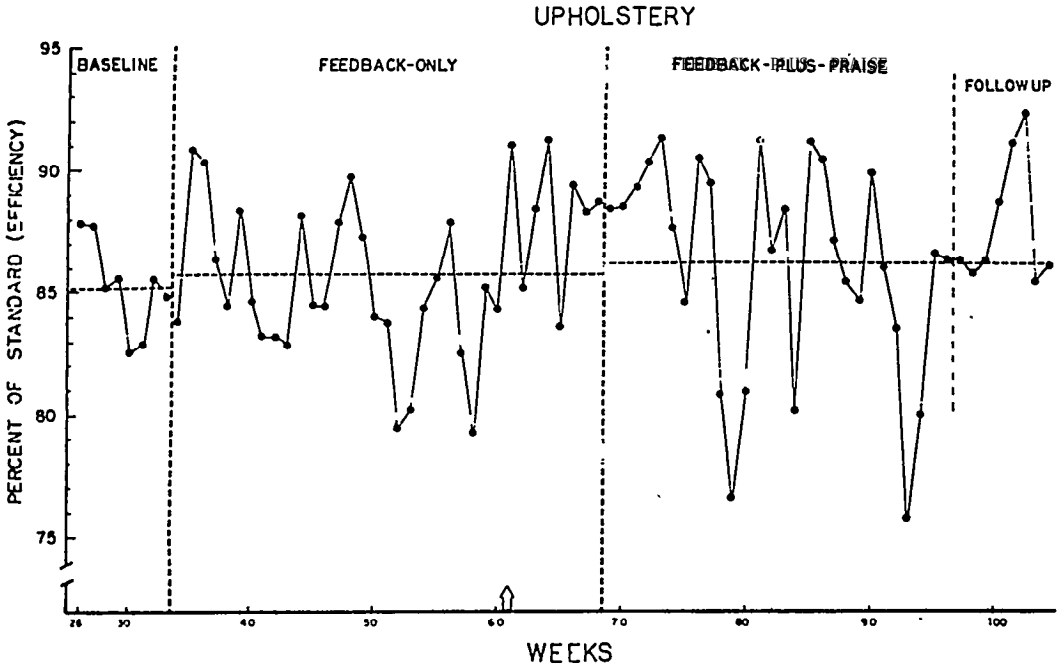

Figure2. Average weekly efficiencies of the Upholstery Department. The feedback portion of the program was applied to this department several months after the feedback-praise intervention was introduced into Fiberglas. Otherwise, legend applications are the same as for Figure 1.

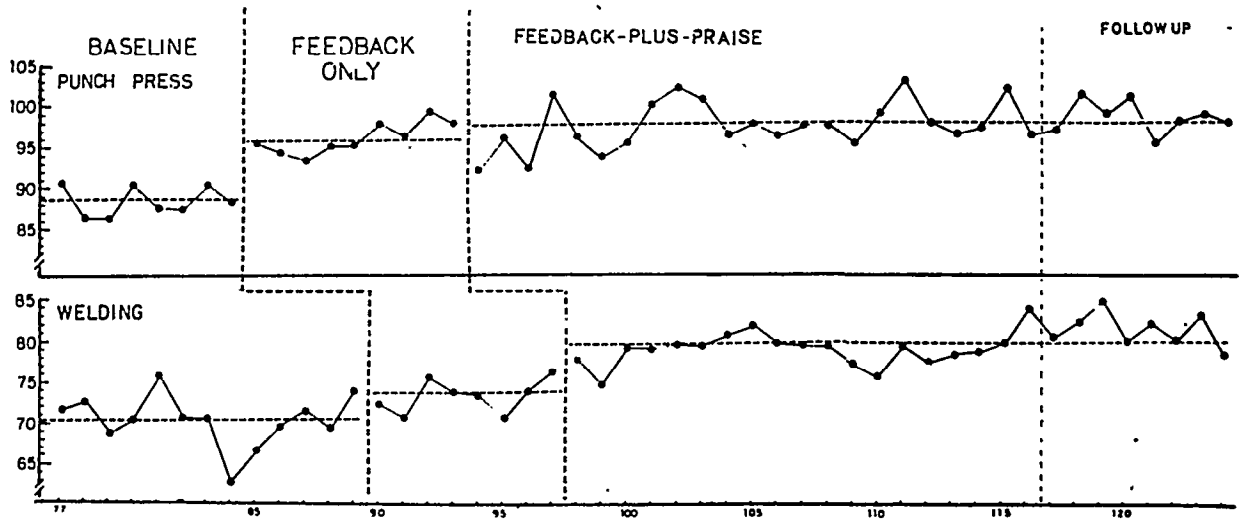

Figure 3;. Average weekly efficiencies during temporally-staggared program introductions into the Punch-press and Welding departments. Chart display for Punch Press occurred well after the feedback-praise intervention in Upholstery. Legends are the same across figures.

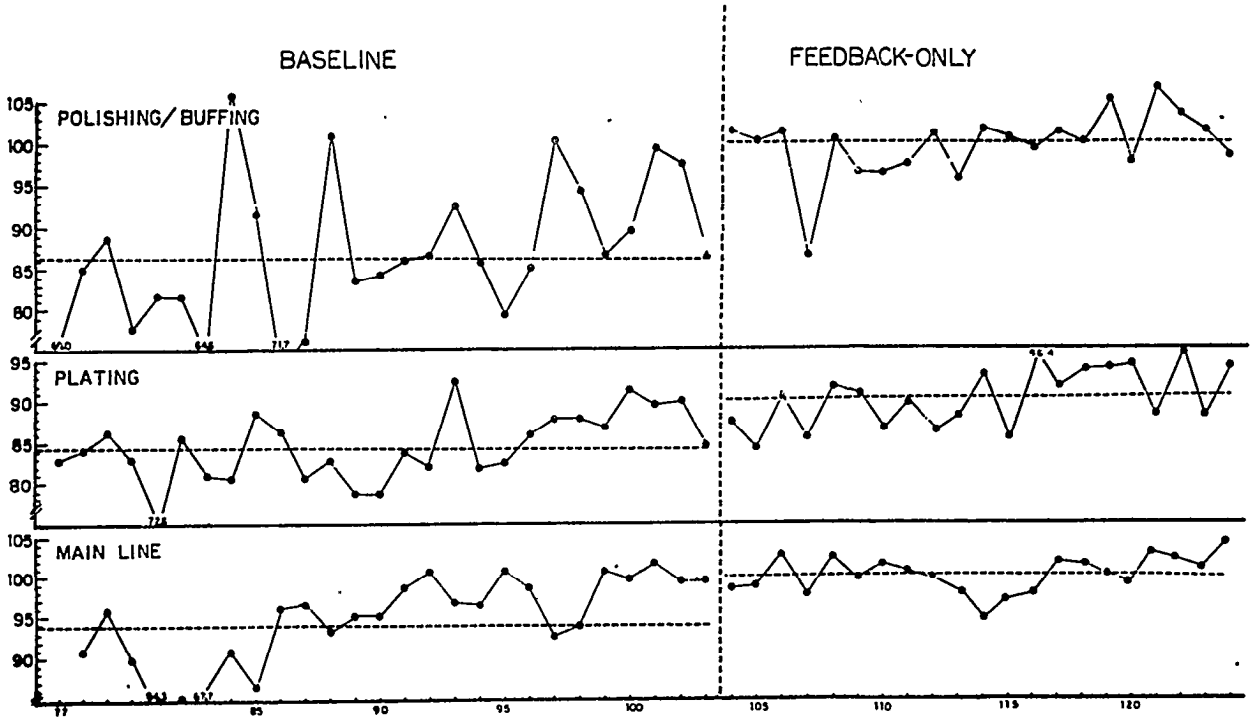

Figure 4. Average weekly efficiencies during program introductions into the Polishing-Buffing, Plating, and Main Line departments, all intitiated after the Welding program. Legends are the same across figures.

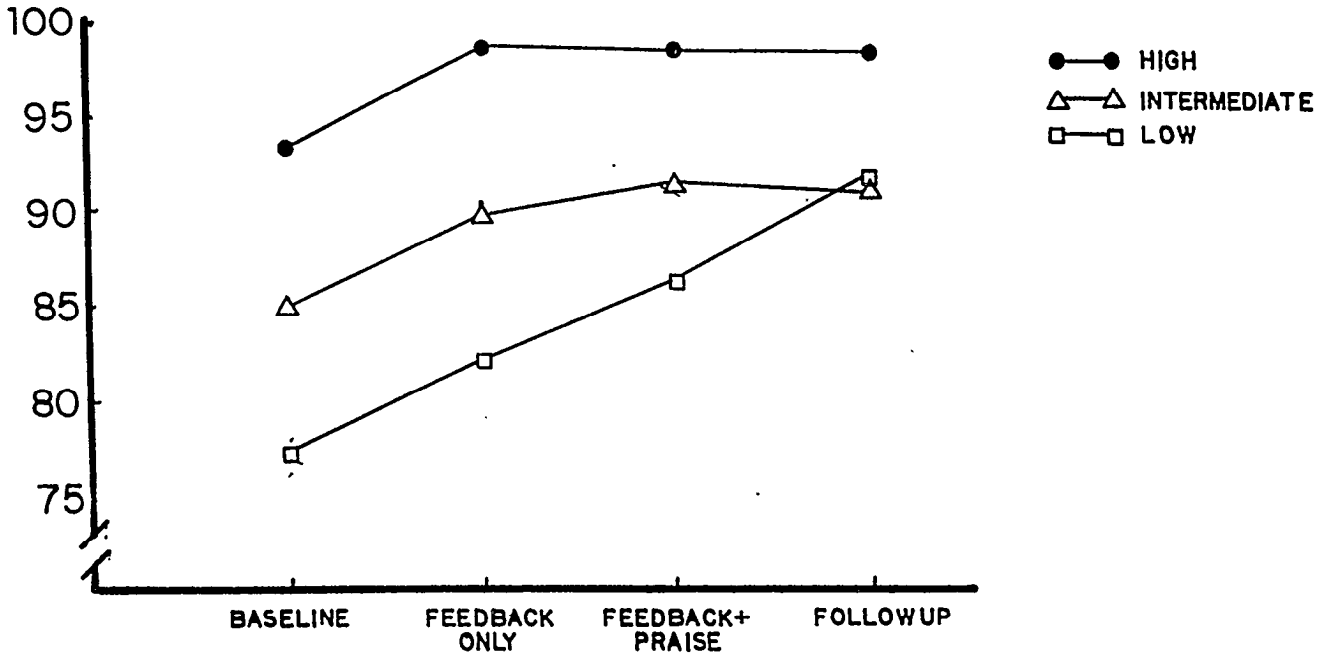

Figure 5. Mean Efficiencies, averaged over seven departments, for the 3 lowest, 3 highest, and remaining intermediate performers (determined from baseline efficiencies) for the respective baseline, feedback-only, feedback plus praise, and followup program phases.

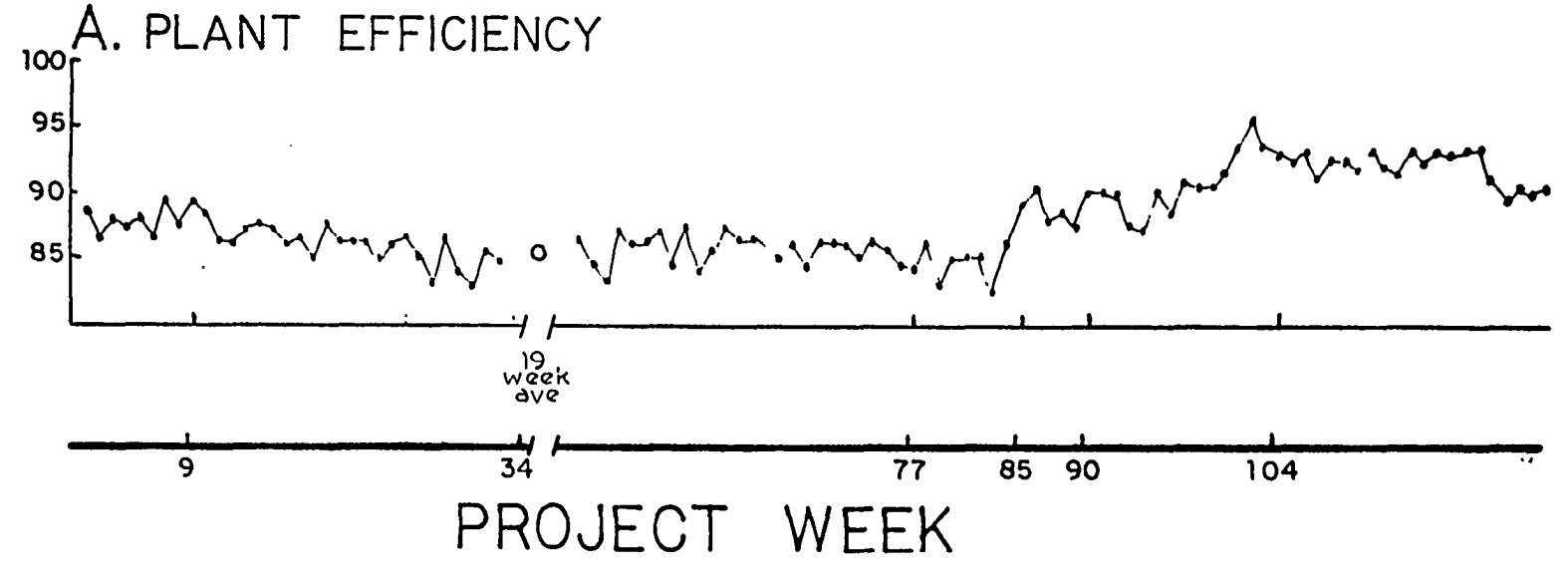

Figure 6. Overall weekly plant efficiencies over the tenure of the work-improvement program (as of February, 1981).

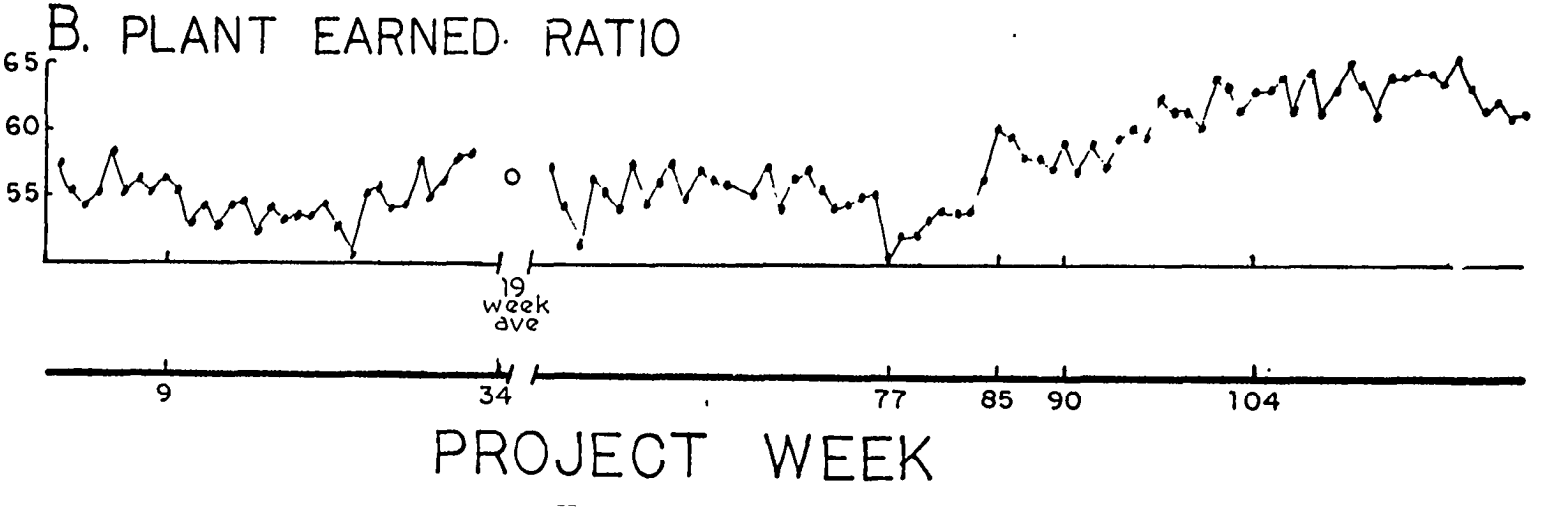

Figure 7. Overall earned ratio over the tenure of the work-improvement program (as of February, 1981).

Thus far, this program successfully now has been extended into various corporate office operations, truck delivery, and most recently to the sales operation. The successes therein have been comparable to those reported for the target factory.

Performance engineering in the public accomodations industry: Better services for increased patronage. Our work in the public accomodations business began in 1973 in a large, 900-plus room, downtown hotel in a major rocky mountain city. The problem addressed was how to get room attendants to clean rooms to a much higher standard of cleanliness. Over 100' attendants and approximately 18 supervisors were involved in this undertaking and, while less than elegant, we were able to achieve this goal within a six month period using an adaptation of the human-performance-engineering approach. Shortly thereafter, we had an opportunity to refine, formalize, and extend the procedures of this preliminary undertaking by adapting our program to address an exceedingly unclean, large, 550-room convention hotel located in the center of a large midwest city (Anderson, Sponsel, Clarke, Brence & Crowell, 1977; 1978). The rooms aptly can be characterized as very unclean at that time, and an outside firm estimated $25,000 (adjusted to the 1981 dollar) to remediate this condition on a one-time-only basis.

The program began by constructing a 70-point checklist that covered in minute detail all facets in need of cleaning for a prototypical room. Initial level of uncleanliness was assessed through application of this checklist to 50 randomly-selected rooms by the executive housekeeper and two assistants who had been carefuLLy trained to accurately and reliably apply this measurement device (85+% agreement among scorers). Additional random room ratings were obtained on this list at key periods throughout the remainder of the program. in order to gradually increase behavioral demands for deep cleaning from the

attendants, the list was divided into three components. Each conformed to different portions of a room. The first (and most difficult) consisted of the 21 points that applied to the bathroom tub and tile areas. Nine supervisors then were reliability trained to use this sublist (three weeks of individual daily charting, discussion, and training of percent-agreement scores with the head housekeeper). Daily reliability checks on unspecified rooms for each supervisor continued throughout the program, and are averaged for the first and last 10 checks of each program component in Figure 8. As seen, all evinced marked improvement in agreement percentages with this list over initial training trials, and then maintained a high agreement average thereafter throughout all portions of the program,

Room attendants then were requested to choose a bathroom from the 15 that each regularly and daily were assigned, and given a maximum of two consecutive days to achieve a score of 18 or better. These scores publicly were charted. In addition, covert (unknown to attendants or supervisors) room checks were conducted randomly during this period on untargeted bathrooms. A reward contingency was introduced after the sixth week of charting. Credits in the form of points were given for scores that achieved 18 or better (such a system has been defined as a token economy). A similar point system was used for supervisor reliability scores. Credits were exchangeable for weekly meal tickets, popular trade stamps, time off with pay, or a meal for two at one of the hotel's expensive restaurants.

All bathrooms achieved a score of 18-21 points within three months of program inauguration (preprogram baseline was 5.5 points). The program then was suspended for 30 days during which random rooms were again assessed (without the knowledge of the attendants or supervisors). Scores declined to an average of 15 points for this period. Fourteen checkpoints then were

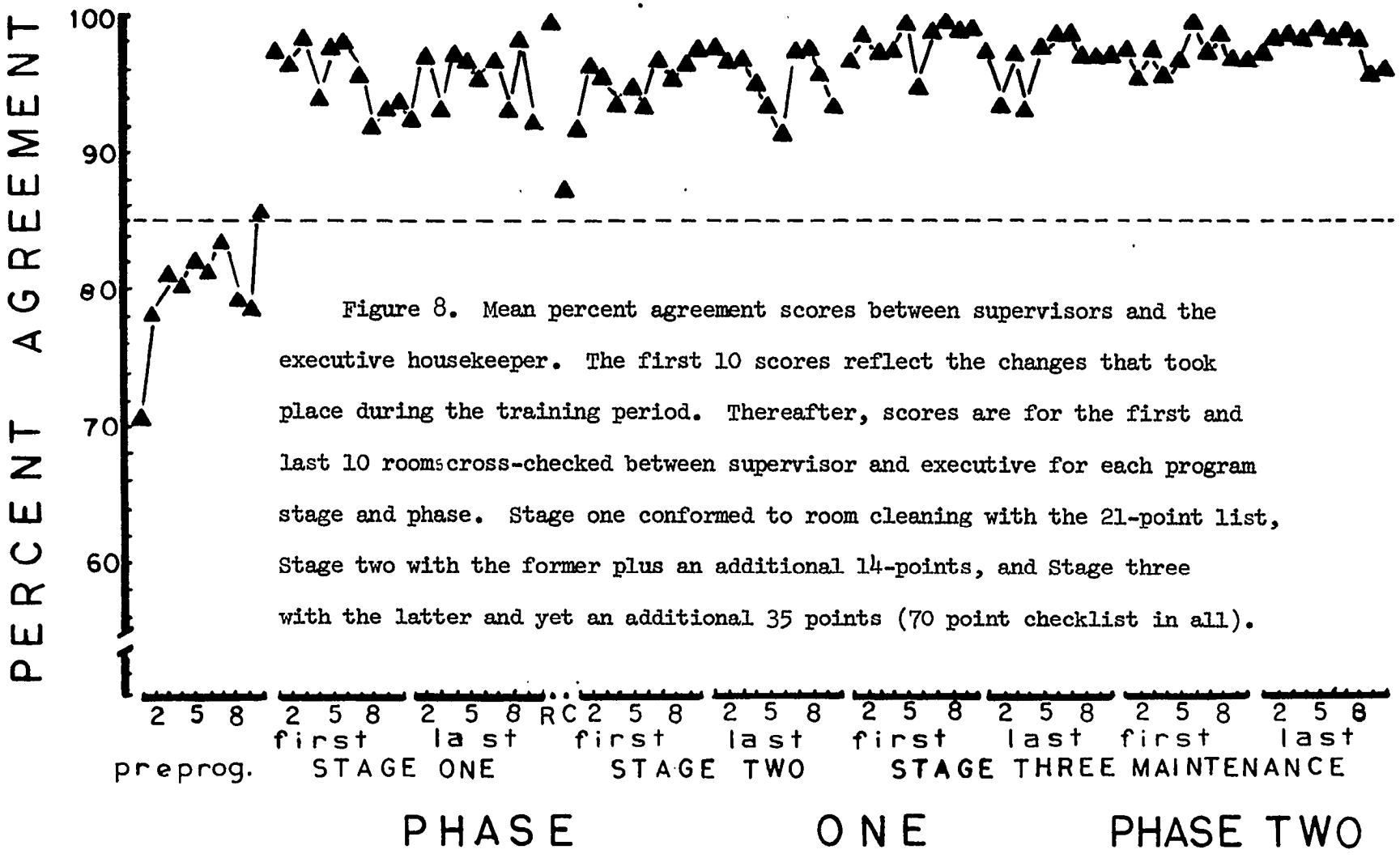

Figure 8. Mean percent agreement scores between supervisors and the executive housekeeper. The first 10 scores reflect the changes that took place during the training period. Thereafter, scores are for the first and last 10 rooms cross-checked between supervisor and executive for each program stage and phase. Stage one conformed to room cleaning with the 21-point list, Stage two with the former plus an additional 14-points, and Stage three with the latter and yet an additional 35 points (70 point checklist in all).

added to the first 21 and the credit (token) system changed so that tokens were given for scores of 33 or better. Covert room and daily reliability checks for supervisors continued. All rooms achieved 33 points or better within another three-month period. Following another brief program suspension during which unannounced room checks again were made, the remaining 35 points were added, and the third stage was inaugurated with the full 70 point checklist. In effect, this gradual addition of checklists leading to the 70 point standard exemplifies a major aspect of the human-performance-engineering undertaking, termed behavior shaping. Shaping thus represents a way of gradually upgrading requirements while taking into account the initial skill level of the employee.

Stage three lasted four months, followed by another withdrawal and assessment period. Finally, a maintenance program was introduced that entailed continued charting, tokens for scores of 65 or better, and the requirement (agreed upon by attendants) of a minimum of three rooms completed per week. This continued off and on for the next four years. All rooms were maintained at the 65-point-or-better average as long as the program was in place. Whenever temporarily withdrawn, scores declined an averege of 19 points.

These data are illustrated in Figure 9 as a time-ordered, multiple-baseline (changing criterions) design. The upper graph of this figure shows, respectively, average points on the 21-point list prior to program inauguration (p), over the first five rooms (Il), on untargeted rooms (T, hatched area), over the last five rooms (I4), and during program withdrawal (W) for Stage One, and for consecutive first five rooms, untargeted rooms, last five rooms, and withdrawals for each stage thereafter. The data for the next 14 points on the list that covers the rest of the bathroom are detailed for respective stages in the intermediate graph of Figure 8, and the data for the remaining 35 points

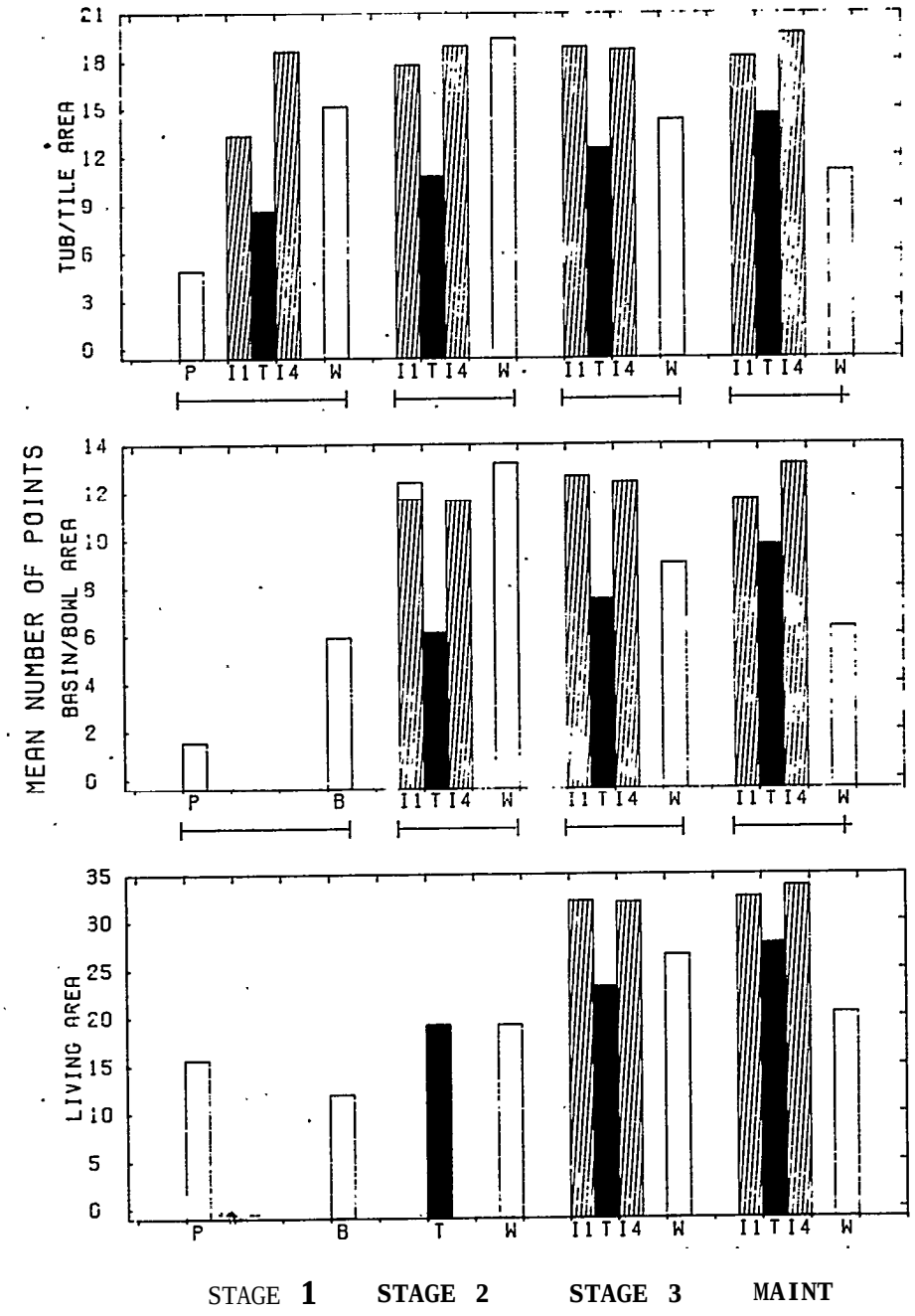

Figure 9. Mean checklist scores, averaged across room attendants, for various checklists and program stages. P designates preprogram baseline, I1 and 14 the intial and last 5 rooms of a program stage, T the score on untarget rooms, and W the score following temporary program withdrawal. Maint refers to the maintenance program.

for respective stages in the lower graph. The temporally-staggared (time-ordered) introduction of each program component also is shown by the different onset of respective lists. Note that marked performance improvements do not occur for any list until its formal introduction as part of the program. There is some evidence, however, of modest "spillover" effects to parts of the room untargeted for change from program influences already underway.

This project can, in several respects, be viewed as a model work-improvement program that rests upon the technology of human performance engineering. The program ingredients of three stages (behavior shaping), daily charting for both attendants and supervisors, ongoing reliability measurements, a token reward system, multiple baseline and full program withdrawal procedures, and complete pre- and post-stage data collection periods that reflect dramatic increases in and maintenance of room cleanliness illustrate how an applied human-engineering technology can effectively increase productivity through strengthening those actions that are pivotally relevant to task outcome. The basic features of this program subsequently were extended to the housemen in charge of cleaning all restaurants and public areas as well as to bellmen and various other personnel within the hotel. Finally, variations of this procedure now have been introduced in other properties of this company, including in Scottsdale, Ariz., Chicago, Ill., Detroit, Mi., Danvers, Mass., and Nashville, Tn.

While I originally intended to present an application of this technology to the sales arena of human work, time and space do not permit. As noted in the presentation, the application chosen here was a real-estate firm that employed the most agents in their "corner" of the state but that only ranked seventh in total dollar volume. Suffice it to say that the application of this technology reaped handsome benefits, including an increase in dollar volume

sufficient for an increase in ranking to Number One while the program remained in effect (cf., Anderson, Crowell, Sucec, Gilligan & Beles, 1978).

Conclusions

There are a number of important features to discern from the preceding projects. First, quite different work populations were involved, ranging (a) from manufacturing to service/sales, (b) from the educated to the relatively unskilled, and (c) from those that resided in large metropolitan areas to those who lived in a mostly rural area. Second, all were conducted during this most recent period when the so-called slowdown in productivity has been at its zenith. This period can be characterized in numerous ways, including (1) as a time in our history following the end of the migration of the farm worker to the city, (2) when union power has been at its greatest, (3) after the "baby boom" has entered the work force, and (4) along with an all-time high proportion of females, (5) when inflation has reached near-record levels, (6) when federal regulations have been their most costly and restrictive, and so forth. In spite of these factors, these projects have in common marked and durable productivity increases that can be directly attributed to a programmatic increase in relevant work behaviors by individual workers.

The reason for this across-board productivity increase is, I believe, conceptually straight forward. Managers were enlightened with principles and techniques consistent with the 1980s; but fully different from those of the past. Those persons then were supervised in the implementation of these techniques until relevant adaptations were complete. Moreover, both manager and front-line worker alike were and remained long-run participants in the behavior-change undertaking. In addition, the techniques that each employed were themselves conceptually easy to grasp. Each entailed, initially, a definition of respectice productivity goals in behavioral terms. For the

furniture manufacturing project, the behaviors targeted for change were number of pieces per unit time. For the hotel illustration, the behaviors were defined in terms of number of checkmarks. And, for the sales example, the behaviors were number of initial and personal, face-to-face client contacts.

Second, behavior measurement systems were established that were accurate, reliable, and unobtrusive to apply. Such was already in place in the furniture example in the form of worker-administered, work-record sheets. Supervisor-applied checklists constituted the measurement strategy for the hotel example, and self-administered record sheets consisting of factual customer information constituted the measurement procedure for the sales illustration. Ways to uniformly collect, collate, and individually record this information were devised in each instance as well. Third, these data were displayed in chart form, sometimes in public and sometimes not for a while. (Preferably, individual performance data should not be displayed for a period of time in order to locate trends as well as to discern whether public introduction per se results in a beneficial behavior increase.) A rule of thumb here is that the introduction of charts, when done without threat or potential censure, will almost always precipitate a beneficial behavioral increase.

Fourth, rewards were located that (1) were potent and relevant to those designated to receive them, (2) that did not "tax" either the company's or manager's resources, (3) that were easy to dispense, and (4) that did not satiate easily. Once the effect(s) of public charting appeared to level off, the reward(s) were introduced only for desired performance increases or for maintenance of acceptable work activity. And, efforts were made to ensure that rewards were not given at any other time. This fourth prescriptive ingredient is predicated upon the established behavioral law that pleasant

consequences increase the likelihood of repeat behaviors. An important supplement to this law is that if positive outcomes occur independent of a behavior, then that response ultimately will disappear from the response repertoire of the worker. We invariantly have discovered that dispensing rewards in terms of charted changes, one can be assured of consistency, accuracy, and longevity of the program. We also have found that the easiest (and often one of the more potent) reward to employ is social supportiveness. However, the proper usage of this category of consequences requires a good deal of training and practice.

Fifth, procedures were used that permitted an assessment of whether or not any changes that resulted occurred because of the above-itemized procedures and not something else. Brief program withdrawal, multiple-baseline, changing criterions, and so forth were examples of proper assessment strategies for a human performance-engineering program. And, as noted in preceding illustrations, these procedures were applied in a way that supported incremental, step-by-step performance changes rather than massive, wholesale behavioral alterations.

A final note. I began this paper with the assertion that our principle efforts to increase productivity rested upon the application of a unique people-change, work-improvement program. In fact, this depiction is not quite accurate. What has been briefly enunciated in this presentation is instead a behavior-change rather than a person-change approach. This distinction between persons and behavior is made because of our view that people do not seem to have changed much over time. In broad perspective, their needs, aspirations, and goals of today appear much the same as those of our forefathers. However, both the manner by which to obtain fulfillment and the expression of these goals and needs clearly has changed over generations. In

effect, it is our contention that to obtain goals and need fulfillment does not necessitate people-changes so much as behavioral adaptations. The major premise of this paper, ,then, is that changing people is basically a straight-forward undertaking. It is based on the presumption that people do not actually change but that behavior both does and must if we are to adjust to our changing surroundings.

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